Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online): 0493-2137
E-Publication: Online Open Access
Vol:54 Issue:08:2021
DOI 10.17605/OSF.IO/PBD8N

THE STATISTICAL OF RESPONSE SURFACE METHODOLOGY AND CENTRAL COMPOSITE DESIGN FOR INNOVATION PADDY HUSKER

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Abstract
This study presents the application of the response surface methodology and central composite design technique in generating the optimal innovation paddy husker for the brown rice mill, when using the four factors. The four factors; spindle of speed (SS), rubber of clearance (CL), rice temperature (TE) and rice of moisture(MO) respectively. Design of Experiment (DOE) by response surface methodology and central composite design was used as a tool in order to generate the suitable run order. All 62 run orders were generated by the full quadratic technique. ANOVA and Regression was used for analysis. The brown rice cracker tests were conducted on kow dauk mali 105 rice. After milling, the percentage of broken rice were calculated and analyzed using Regression Analysis and Analysis of Variance (ANOVA). The response optimization was SS = 1,500 rpm, CL= 1.6 millimeters, TE= 20.25 degree Celsius and MO = 11.65 percentage respectively. At a significant level $\alpha = 0.05$, the values of Regression coefficient, R2 (adjust) were 99.30 %. The optimal values gave 10.00% broken rice.

Keywords: Statistical, Response surface methodology, central composite design, regression model, optimal, paddy husker

INTRODUCTION

The quality of peeled rice is depending on many factors such as rice strain, the rate of feeding, clearance between a rubber to rubber cylinder and paddy moisture content which usually are controlled not to be exceed 14%. But the most important factor is the type of the abrasives (S. Bangphan and S. Lee.,2006),(S. Bangphan, S. Lee and S. Jomjunyong.,2007). Implications of Rice Milling: In rice milling, the bran layers and germ removed during polishing are high in fiber, vitamins and minerals as well as protein. Their removal results in loss of nutrients, especially in substantial losses of B vitamins. Polishing rice reduces the thiamin content of rice by over 80%. Parboiling results in gelatinization of the starch and disintegration of the protein in the endosperm resulting in inward shift of water-soluble vitamins to the endosperm. Parboiled rice is therefore higher in B vitamins than raw milled rice (Oh C.H. and S.H. Oh., 2004). and shown in Table1.

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Table 1 Nutrient content of rice (Oh C.H. and S.H. Oh.,2004),(S. Bangphan., P Bangphan, and T.Boonkang.,2013).

Mg/10g	Brown rice	Polished rice
Thiamine	0.34	0.07
Riboflavin	0.05	0.03
Niacin	4.7	1.6
Iron	1.9	0.5
Magnesium	187.0	13.0

Brown Rice is Superior to Polished Rice: Brown rice has high dietary fiber (a gentle laxative, prevents gastro-intestinal diseases and good for diabetes sufferers); rich in B vitamins and minerals (prevents beriberi); and high in fat (energy source). Also it has been reported that brown rice contains high phytic acid (antioxidant, anti-cancer); it decreases serum cholesterol (prevents cardio vascular diseases); and it is considered a low glycemic index food (low starch, high complex carbohydrates which decreases risk to type diabetes).The enhancement of rice supply is another advantage of brown rice relative to polished or white rice. Post harvest researchers say that the milling recovery in brown rice is 10% higher than polished rice (Garrow J.S. et al.,2000). There is the other benefit of brown rice – economics the fuel savings in milling is 50-60% because the polishing and whitening steps are eliminated. It follows that the milling time is also shortened; labor is less; and the cost of equipment (if the mill is dedicated to brown rice) is much lower because the miller doesn’t have to install polishers and whiteners. The enhancement in output volume and the economy in milling constitute the business opportunity in brown rice (Rogelio V. Cuyno.,2003).

Milling is the primary difference between brown and white rice. The varieties may be identical, but it is in the milling process where brown rice becomes white rice. Milling, often called "whitening", removes the outer bran layer of the rice grain. Milling affects the nutritional quality of the rice. Milling strips off the bran layer, leaving a core comprised of mostly carbohydrates. In this bran layer resides nutrients of vital importance in the diet, making white rice a poor competitor in the nutrition game the following chart shows the nutritional differences between brown and white rices. Fiber is dramatically lower in white rice, as are the oils, most of the B vitamins and important minerals.

Unknown to many, the bran layer contains very important nutrient such as thiamine, an important component in mother’s milk (Wood Rebecca,1988). Brown rice (hulled rice) is composed of surface bran (6–7% by weight), endosperm (E90%) and embryo (2–3%) [8]. White rice is referred to as milled, polished or whitened rice when 8–10% of mass (mainly bran) has been removed from brown rice (Chen H. and Siebenmorgen T.J.,1997). During milling, brown rice is subjected to abrasive or friction pressure to remove bran layers resulting in high, medium or low degrees of milling depending on the amount of bran removed (Chen H. and Siebenmorgen T.J.,1997),(Chen H., Siebenmorgen T.J. and Griffin, K.,1998),(Kennedy G., Burlingame B. and Nguyen N. ,2002),(Itani T., Tamaki M., Arai E. and Horino T.,2002). Milling brings about considerable loss of nutrients and affects the edible properties of milled rice (Chen H.

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and Siebenmorgen T.J.,1997),(Chen H., Siebenmorgen T.J. and Griffin, K.,1998). As most cereals, rice does not show a homogeneous structure from its outer (surface) to inner (central), (Itani T., Tamaki M., Arai E. and Horino T.,2002). As a consequence, information on the distribution of nutrients will greatly help in understanding the effect of milling and aid in improving sensory properties of rice while retaining its essential nutrients as much as possible (Jianfen Liang et al.,2008).

Therefore the purpose of this research is to generate between clearance of rubber and spindle of speed with moisture and temperature of rice using Design of Experiment(DOE) by Response Surface Methodology(RSM) and Central Composite Design (CCD) in order to generate the suitable factors. To determine the optimum value of the production process in the paddy sheller by controlling the specified variable to find the best response, the percentage of broken rice.

MATERIALS AND METHODS

Materials

The most outer rough shell of paddy is removed. Rubber roll sheller Figure 1 is the most common machine that is used for paddy shelling, however friction type browner is sometimes used as a sheller. Paddy goes between six rubber rollers that are rotating in opposite direction with different velocities. There is a small clearance between the rollers so that when paddy passes through, it is subjected to some shear forces and husk is removed from production process of rice milled.

Methods

Design of experiments (DOE) by Response Surface Methodology (RSM) and Central Composite Design (CCD) is a collection of statistical and mathematical techniques useful for developing, improving and optimizing process and new products, as well as in the improvement of existing product designs. RSM can take unknown response function and approximate it by coded variables where these coded variables are usually defined to be dimensionless with zero mean and the same spread or standard deviation. Usually a low order polynomial in some relatively small region of the independent variable space is generated. The approach presented in this paper is a statistically based method which combines design of experiments (DOE) and response surface methodology (RSM), (Myers R. H. and Montgomery D. C.,1995). RSM is generally conducted in three phases, as emphasized according to research conducted (Myers R.H. and Montgomery D.C., 2002). The fundamentals of RSM are set out in the semina papers of (Myers R.H. and Montgomery D.C., 2002),(Box G.E.P. and Wilson K.B.,1951),(Box G.E.P., Draper N.R.,1959),(Box G.E.P. and Draper N.R.,1987). Further developments are drawn together in three key review articles, namely those of (Hill W.J. and Hunter W.G.,1966),(Myers R.H., Khuri A.I., Carter W.H.,1989),(Myers R.H., Montgomery D.C., Vining G.G., Borror C.M. and Kowalski S.M.,2004).

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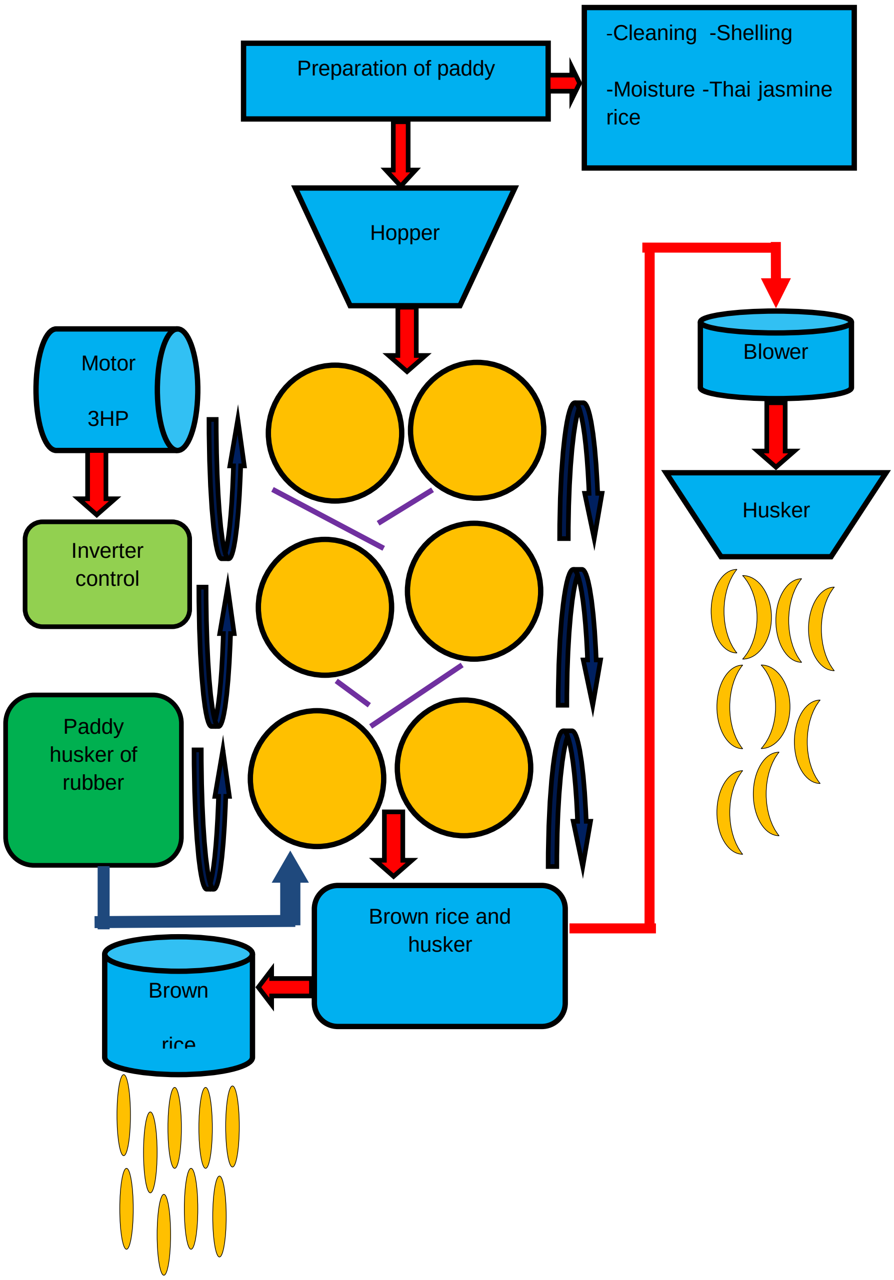

Figure 1 Diagram of innovation paddy husker production process

The example presented above demonstrates that designs taken from the RSM paradigm can be used to good effect in a traditional agricultural setting and this point is further underscored by the work of (Khuri A.I. and Cornell J.A., 1987),(Edmondson R.N.,1991). And according to Hill and Hunter, RSM method was introduced by (Box G.E.P. and Wilson K.B.,1951),(Box G.E.P., Draper N.R.,1959) suggested to use a first-

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degree polynomial model to approximate the response variable (Accessed 22January 2021) suggested this model is only an approximation, not accurate, but such a model is easy to estimate and apply, even when little is known about the process (Accessed 22January 2021). The resulting surfaces, usually linear or quadratic, are fitted to these points. Often statistical methods such as design of experiments are used to determine where in the design space these points should be located in order to obtain best possible fit. The fundamentals of RSM are set out in the seminal papers of (Jianfen Liang et al.,2008),(Box G.E.P. and Wilson K.B.,1951),(Box G.E.P., Draper N.R.,1959), (Khuri A.I. and Cornell J.A.,1987). Further developments are drawn together in three key review articles, namely those of (Khuri A.I. and Cornell J.A.,1987),(Hill W.J. and Hunter W.G.,1966),(Myers R.H., Montgomery D.C., Vining G.G., Borror C.M. and Kowalski S.M.,2004). It is clear from these articles that research into RSM within academia continues to flourish and that the associated techniques are used extensively in industry (Edmondson R.N.,1991). provides an interesting application of RSM to greenhouse experiments and, in addition, presents some valuable insights into the use of RSM within an agricultural as opposed to an industrial setting. In addition (Khuri A.I. and Cornell J.A.,1987).] analyze an experiment on snap bean yield conducted using a central composite design. In this paper we use linear polynomials to create the response surface. The creation of such response surface models to approximate detailed computer analysis codes is particularly appropriate in the preliminary design stages when comprehensive trade-offs of multiple performance and economic objectives is critical. In many cases, either a second-order model is used. If there is curvature in the system, then a polynomial of a higher degree, for the case of four independent variables, the second-order model as in Equation (1)

$$y_k = \beta_0 + \sum_{i=1}^{n} \beta_i x_i + \sum_{i=1}^{n} \beta_{ii} x_1^2 + \sum_{i=1}^{n-1} \sum_{j=1}^{n-1} \beta_{ij} x_i x_j \quad (1)$$

where y is the studied response (percentage of broken rice, (BR)) and where □ are the coefficients which have calculated using an appropriate method such as the least square method. When the result estimated surface is an adequate approximation of the true response function, the results will be approximately equivalent to analysis of the actual system. The model parameters can be approximated whenever proper experimental designs are used to collect the data. The DOE simulation was accomplished with three parameters: between rubber of clearance, spindle of speed and rice of moisture respectively. It was performed according shown in Table 2 and 3, and diagram of paddy husker production process shown in Figure 2. A model fitting was accomplished for the first 24-CCD shown in Table 3.

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Table 2 DOE parameters.

Parameter	Variable	Lower Limit	Upper Limit
Spindle of speed, SS	X_1(RPM)	1,440	1,480
Rubber of clearance, CL	X_2(mm.)	1.0	1.4
Rice of temperature, TE	X_3(°C)	25	35
Rice of moisture , MO	X_4(percentage)	10	14

The four defined variables are very important to the production process of paddy husking to achieve 100% brown rice quality, and the related variables consisted of the machines used in the experiment, relative humidity test time seasons, and natural disasters. All of these things are important to the process.

Table 3 Units for parameters properties.

Run	Std Order	Run Order	Pt Type	Blocks	SS	CL	TE	MO	Yields
1	61	1	0	1	0	0	0	0	-
2	18	2	-1	1	2	0	0	0	-
3	54	3	-1	1	0	0	0	-2	-
4	47	4	1	1	1	1	1	1	-
5	57	5	0	1	0	0	0	0	-
6	26	6	0	1	0	0	0	0	-
7	11	7	1	1	-1	1	-1	1	-
8	32	8	1	1	-1	-1	-1	-1	-
9	6	9	1	1	1	-1	1	-1	-
10	49	10	-1	1	2	0	0	0	-
11	46	11	1	1	-1	1	1	1	-
12	55	12	-1	1	0	0	0	2	-
13	21	13	-1	1	0	0	-2	0	-
14	45	14	1	1	1	-1	1	1	-
15	53	15	-1	1	0	0	2	0	-
16	1	16	1	1	-1	-1	-1	-1	-
17	48	17	-1	1	-2	0	0	0	-
18	52	18	-1	1	0	0	-2	0	-
19	59	19	0	1	0	0	0	0	-
20	16	20	1	1	1	1	1	1	-
21	10	21	1	1	1	-1	-1	1	-
22	38	22	1	1	-1	1	1	-1	-
23	41	23	1	1	1	-1	-1	1	-

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Table 3 (Cont.) Units for parameters properties.

Run	Std Order	Run Order	Pt Type	Blocks	SS	CL	TE	MO	Yields
24	28	24	0	1	0	0	0	0	-
25	24	25	-1	1	0	0	0	2	-
26	33	26	1	1	1	-1	-1	-1	-
27	12	27	1	1	1	1	-1	1	-
28	5	28	1	1	-1	-1	1	-1	-
29	62	29	0	1	0	0	0	0	-
30	22	30	-1	1	0	0	2	0	-
31	34	31	1	1	-1	1	-1	-1	-
32	42	32	1	1	-1	1	-1	1	-
33	17	33	-1	1	-2	0	0	0	-
34	4	34	1	1	1	1	-1	-1	-
35	39	35	1	1	1	1	1	-1	-
36	40	36	1	1	-1	-1	-1	1	-
37	50	37	-1	1	0	-2	0	0	-
38	25	38	0	1	0	0	0	0	-
39	51	39	-1	1	0	2	0	0	-
40	19	40	-1	1	0	-2	0	0	-
41	3	41	1	1	-1	1	-1	-1	-
42	43	42	1	1	1	1	-1	1	-
43	60	43	0	1	0	0	0	0	-
44	44	44	1	1	-1	-1	1	1	-
45	13	45	1	1	-1	-1	1	1	-
46	23	46	-1	1	0	0	0	-2	-
47	31	47	0	1	0	0	0	0	-
48	58	48	0	1	0	0	0	0	-
49	29	49	0	1	0	0	0	0	-
50	35	50	1	1	1	1	-1	-1	-
51	15	51	1	1	-1	1	1	1	-
51	15	51	1	1	-1	1	1	1	-
52	9	52	1	1	-1	-1	-1	1	-
53	7	53	1	1	-1	1	1	-1	-
54	8	54	1	1	1	1	1	-1	-
55	30	55	0	1	0	0	0	0	-
56	27	56	0	1	0	0	0	0	-
57	14	57	1	1	1	-1	1	1	-
58	56	58	0	1	0	0	0	0	-
59	36	59	1	1	-1	-1	1	-1	-
60	2	60	1	1	1	-1	-1	-1	-
61	37	61	1	1	1	-1	1	-1	-
62	20	62	-1	1	0	2	0	0	-

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Statistical Methods and Software

The analysis and results of the experimental design were studied and interpreted by MINITAB RELEASE 19.00 (PA, USA licensed to Department of Industrial Engineering, Faculty of Engineering, Rajamangala University of Technology Lanna, Chiang Mai, Thailand) statistical software to estimate the response of the dependent variable. The response curves and contour plots are also generated. After peeling, the percentage of broken rice (BR) were calculated and analyzed using Regression analysis and Analysis of Variance (ANOVA).

RESULTS AND DISCUSSION

Results

The DOE simulation was accomplished with four parameters: spindle of speed, rubber of clearance, rice of temperature and rice of moisture respectively. It was performed according shown in Table 2 and 3, and brown rice peeling machine in Figure.1. A model fitting was accomplished for the first 24 Factorial Design shown in Table 4. The independent (SS, CL, TE, and MO) and the dependent variables were fitted to the second-order model equation and examined in terms of the goodness of fit. The analysis of variance (ANOVA) was used to evaluate the adequacy of the fitted model. The R-square value (determination coefficient) provided a measure of how much of the variability in the observed response values could be explained by the experiment factors and their interactions. DOE order defines the sequence that variables should be introduced in response surface analysis. Table 4 shows the results according to simulated analysis performed in MINITAB Release 19.00 used for simultaneous optimization of the multiple responses. The desired goals for each variable and response were chosen. All the independent variables were kept within range while the responses were either maximized or minimized. The significant terms in different models were found by analysis of variance (ANOVA) for each response. Significance was judged by determining the probability level that the F-statistic calculated from the data is less than 5%. The model adequacies were checked by R2, adjusted-R2 (adj-R2). The coefficient of determination, R2, is defined as the ratio of the explained variation to the total variation according to its magnitude. It is also the proportion of the variation in the response variable attributed to the model and was suggested that for a good fitting model, R2 should not be more than 75 %. A good model should have a large R2, adj-R2. Response surface plots were generated with MINITAB Release 19.00. The result is not only the value for which the initial variable, but it defined. Rather than, it can imply that the selectivity of the experimental design method, the response surface methodology, and the design of the central composite design can be significantly used in the test. Variable control is a very important factor in experimental design. In this study, variables were controlled to be in the assumption that the desired outcome was the lowest for the percentage of broken rice, and three iterations and confirmation trials were performed to increase research confidence. In addition, ANOVA and regression analysis were both confidently analyzed in the research. Specifically, the adjusted decision coefficient was more than ninety percent. It was shown that the experiments in the paddy husking process were effective.

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Table 4 DOE set and results.

Run	Std Order	Run Order	Pt Type	Blocks	SS	CL	TE	MO	Yields
1	61	1	0	1	1460	1.2	30	12	25.41
2	18	2	-1	1	1500	1.2	30	12	11.99
3	54	3	-1	1	1460	1.2	30	8	36.22
4	47	4	1	1	1480	1.4	35	14	18.42
5	57	5	0	1	1460	1.2	30	12	24.92
6	26	6	0	1	1460	1.2	30	12	25.40
7	11	7	1	1	1440	1.4	25	14	32.19
8	32	8	1	1	1440	1.0	25	10	34.04
9	6	9	1	1	1480	1.0	35	10	29.11
10	49	10	-1	1	1500	1.2	30	12	11.98
11	46	11	1	1	1440	1.4	35	14	34.85
12	55	12	-1	1	1460	1.2	30	16	26.81
13	21	13	-1	1	1460	1.2	20	12	27.44
14	45	14	1	1	1480	1.0	35	14	18.17
15	53	15	-1	1	1460	1.2	40	12	33.34
16	1	16	1	1	1440	1.0	25	10	34.60
17	48	17	-1	1	1420	1.2	30	12	33.41
18	52	18	-1	1	1460	1.2	20	12	27.48
19	59	19	0	1	1460	1.2	30	12	25.49
20	16	20	1	1	1480	1.4	35	14	18.44
21	10	21	1	1	1480	1.0	25	14	11.45
22	38	22	1	1	1440	1.4	35	10	30.34
23	41	23	1	1	1480	1.0	25	14	11.42
24	28	24	0	1	1460	1.2	30	12	25.53
25	24	25	-1	1	1460	1.2	30	16	26.56
26	33	26	1	1	1480	1.0	25	10	26.82
27	12	27	1	1	1480	1.4	25	14	12.91
28	5	28	1	1	1440	1.0	35	10	32.15
29	62	29	0	1	1460	1.2	30	12	24.88
30	22	30	-1	1	1460	1.2	40	12	33.70
31	34	31	1	1	1440	1.4	25	10	32.15
32	42	32	1	1	1440	1.4	25	14	32.08
33	17	33	-1	1	1420	1.2	30	12	33.48
34	4	34	1	1	1480	1.4	25	10	24.14
35	39	35	1	1	1480	1.4	35	10	26.42
36	40	36	1	1	1440	1.0	25	14	32.45
37	50	37	-1	1	1460	0.8	30	12	26.04

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Table 4 (Cont.) DOE set and results.

Run	Std Order	Run Order	Pt Type	Blocks	SS	CL	TE	MO	Yields
38	25	38	0	1	1460	1.2	30	12	25.60
39	51	39	-1	1	1460	1.6	30	12	23.67
40	19	40	-1	1	1460	0.8	30	12	24.84
41	3	41	1	1	1440	1.4	25	10	31.04
42	43	42	1	1	1480	1.4	25	14	12.54
43	60	43	0	1	1460	1.2	30	12	24.88
44	44	44	1	1	1440	1.0	35	14	35.56
45	13	45	1	1	1440	1.0	35	14	34.98
46	23	46	-1	1	1460	1.2	30	8	36.58
47	31	47	0	1	1460	1.2	30	12	24.85
48	58	48	0	1	1460	1.2	30	12	24.81
49	29	49	0	1	1460	1.2	30	12	24.82
50	35	50	1	1	1480	1.4	25	10	24.59
51	15	51	1	1	1440	1.4	35	14	34.18
52	9	52	1	1	1440	1.0	25	14	32.43
53	7	53	1	1	1440	1.4	35	10	30.58
54	8	54	1	1	1480	1.4	35	10	26.88
55	30	55	0	1	1460	1.2	30	12	24.83
56	27	56	0	1	1460	1.2	30	12	24.82
57	14	57	1	1	1480	1.0	35	14	18.43
58	56	58	0	1	1460	1.2	30	12	24.85
59	36	59	1	1	1440	1.0	35	10	32.43
60	2	60	1	1	1480	1.0	25	10	28.10
61	37	61	1	1	1480	1.0	35	10	30.58
62	20	62	-1	1	1460	1.6	30	12	23.49

Discussion

Response surfaces equations were obtained from design of experiments. Using all values (tests 1 to 62) to the system analysis, the following polynomial equations were generated: The estimated regression coefficients for broken rice using data in uncoded units:

$$y = (-3823.67x_0) + (5.08919x_1) + (-27.9212x_2) + (-17.8906x_3) + (105.367x_4) + (-0.00160166x_1x_2) + (-4.79781x_2x_2) + (0.0521235x_3x_3) + (0.391553x_4x_4) + (0.0116406x_1x_2) + (0.00949688x_1x_3) + (-0.0830078x_1x_4) + (-0.0509375x_2x_3) + (1.75078x_2x_4) + (0.101719x_3x_4) \quad (2)$$

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DOI 10.17605/OSF.IO/PBD8N

As in Equation (2) is generate the graphic shown in Figure 2 shown the standardized effects considering SS, CL,TE and MO between percentage with residual. Main solutions are positioned at 1,440 to 1,480 RPM, rubber of clearance between 1.0 to 1.4, 25, and 35 degree Celsius distance and there is a range between 10 and 14 percentages of moisture respectively where it is allowable to use other distances shown in Table 2 and Table 3 DOE parameter. Result of the analysis of variance for yields is given in Table 5.
The estimate of the variance due to pure error was possible. Hence, the adequacy of the fitted model could be checked by comparing the error component due to the model to that one due to experimental error. The test statistic was the F-ratio given by the estimate of the variance due to lack of fit (MSLOF) and the estimate of the variance due to pure error (MSPE). In general, lack of fit of the model is suspected when the computed value of F is significant. As shown in Tables 5 , the percentage of broken rice (yields) are listed. The parameters of the combined model in Equation (2) were estimated by fitting the 62-term polynomial to the experimental data here reported. The estimated residual variance was MSE = 0.306. Using the two replicates, the experimental error variance was estimated such as MSPE = 0.154 with 37 degree of freedom for yields. Having obtained the estimation of the variance due to lack of fit (MSLOF = MSE - MSPE), based on the LOF test for response yields, the combined model shown in Equation (2) was augmented with four terms of the full quadratic model. In fact, the value of the F-statistic, for testing the presence of lack of fit of model in Equation (2) was F = 5.67 with a P-value of 0.000 for yields. This model was maintained. From the analysis of variance table, the R2 statistics for the two combined models were computed and their values were R2=0.9946 with an R2 (adjust) = 0.9930 respectively. The coefficient of determination corrected for the number of terms in the equation should be always preferred to R2 as it gives a more stable measure to the model adequacy.

Table 5 Analysis of variance for yields.

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Regression	14	2672.29	2672.29	190.878	623.38	0.000
Linear	4	1968.81	330.06	82.516	269.49	0.000
SS	1	1558.04	27.55	27.545	89.96	0.000
CL	1	16.82	0.18	0.182	0.59	0.445*
TE	1	82.19	46.71	46.707	152.54	0.000
MO	1	311.76	259.22	259.217	846.57	0.000
Square	4	272.88	272.88	68.221	222.80	0.000
SS*SS	1	45.10	23.47	23.474	76.66	0.000
CL*CL	1	12.78	2.11	2.106	6.88	0.012
TE*TE	1	74.71	97.11	97.113	317.16	0.000
MO*MO	1	140.29	140.29	140.292	458.18	0.000
Interaction	6	430.60	430.60	71.767	234.38	0.000
SS*CL	1	0.07	0.07	0.069	0.23	0.636*
SS*TE	1	28.86	28.86	28.861	94.26	0.000
SS*MO	1	352.78	352.78	352.783	1152.15	0.000
CL*TE	1	0.08	0.08	0.083	0.27	0.605*

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Table 5 (Cont.) Analysis of variance for yields.

Source	DF	Seq SS	Adj SS	Adj MS	F	P
CL*MO	1	15.69	15.69	15.694	51.25	0.000
TE*MO	1	33.11	33.11	33.109	108.13	0.000
Residual Error						
	47	14.39	14.39	0.306		
Lack-of-Fit	10	8.71	8.71	0.871	5.67	0.000
Pure Error	37	5.68	5.68	0.154		
Total	61	2686.68				

Table 6 the regression of ANOVA and coefficients for broke rice of percentage.

Factors regression coefficients	regression of ANOVA		estimated	
	F	P	R^2	$R^2_{(adjust)}$
SS, CL, TE and MO	23.38	0.000	0.9946	0.9930

The estimated regression coefficients for yields p-value = 0.000 was constant and R-Sq(adjust) = 99.30% and Table 7 shows response optimization of broken rice. There was significant evidence of lack of fit at a = 0.05. Therefore, this study can conclude that the true response surface is explained by the linear model. To study the effects of four factors, 24 = 32 runs (replicated = 62 runs) are required. Due to space limitations, the treatments, factor values, and the corresponding responses are not shown. Analysis of variance method (ANOVA) is used to find factors with significant effects. The response taken from Table 5 and Table 6 revealed that the square coefficients of spindle of speed (X1), rubber of clearance (X2), rice of temperature (X3), and rice of moisture (X4), have a remarkable effect on the broken rice yield. Moreover, all the linear and interaction terms of four factor presented in significant effects on the broken rice yield at 5% probability level. Since all coefficients of the above Equation (2) are all negative, the response surface is suggested have a normal probability plot point in Fig.2. A significantly brown rice peel was observed as spindle of speed, rubber of clearance, rice of temperature and rice of moisture addition increased ($P < 0.05$, Figure 4) parameters of the response optimization. In Fig.3 presents a graphical representation of one of the response surfaces generated through RSM and CCD using a full quadratic model of spindle of speed (X1), rubber of clearance (X2), rice of temperature (X3), and rice of moisture (X4), to predict the broken rice. As depicted, the normalized search direction to minimize the brown rice is (-low, + high). In Figure 4 shows interaction surface plot of yields between X1, X2, X3, X4 and Table 7 shows predicted response for new design points using model for broken rice.

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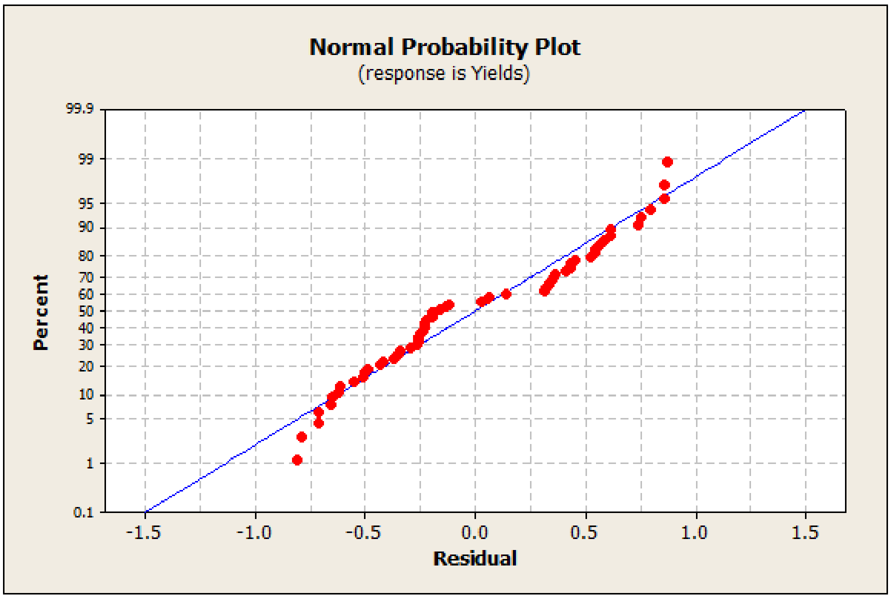

Figure 2 Response is yields of normal probability plot

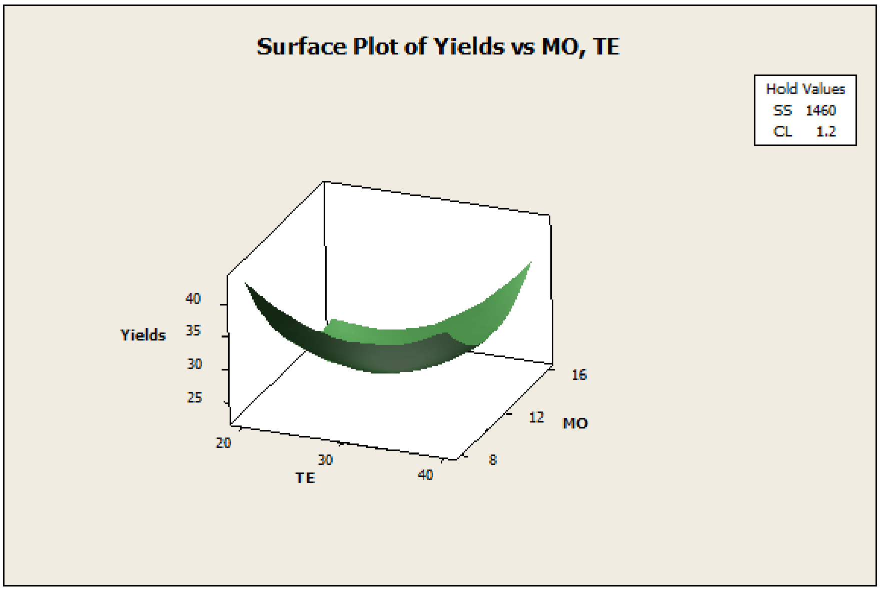

Figure 3 Surface plot of yields vs. MO with TE

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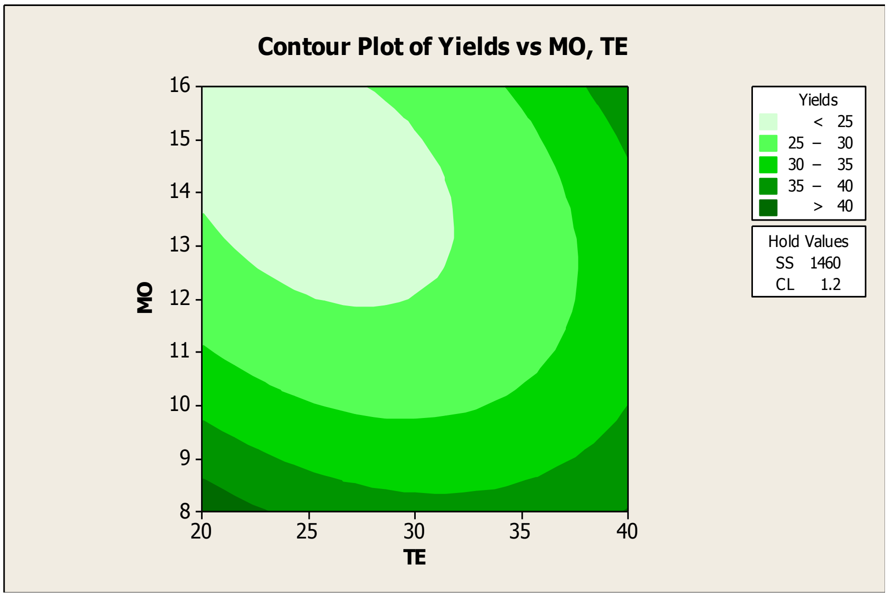

Figure 4 Contour plot of yields vs. MO with TE

Table 7 Response optimization.

Parameters Goal	Lower	Target	Upper	Weight	Import
Yields Target	5	10	15	1	1
Global Solution SS = 1,500 CL = 1.6 TE = 20.2448 MO = 11.6527 Predicted Responses Yields = 10, desirability = 1.000000					

Conclusion and Further research

The results of this study have clearly indicated response surface methodology and central composite design is an effective method for optimization of broken rice. Response surface methodology and central composite design was successfully applied to optimize SS, CL TE and MO in brown rice that was not paddy. When productions into the formulation, the value of the F-statistic, for testing the presence of lack of fit of model in Equation (2) was F = 5.67 with a P-value of 0.000 for yields. This model was maintained. From the analysis of variance table, the optimized levels of R-Squire (adjust) was 99.30 % and standard deviation (σ) was 0.553350 yielded good quality milling. The statistical fitted models and the contour plot of responses, can be used to predict values of responses at any point inside the experimental space and can be successfully used to optimize the brown rice milling machine. Also, the size and amount of this surface degradation was noticeably increased as a function of exposure time. The response surface methodology and central composite design was used. The optimal composition of the brown rice established (run order 62) was: SS = 1,500 round per minute with CL =1.6 millimetres, TE = 20.25 degree Celsius grams and MO =11.65 percentage. The optimal values for the brown rice peeling parameters were good rice response optimization (broken rice) of 10.00 % and composite desirability = 1. The statistical fitted models and the contour plot of responses, can be used to predict values of responses at any point inside the experimental space and can be successfully used to optimize the paddy husker by medium brown rice milling machine 6 rubber type.

This research creates innovation for the peeling process. that is to say, in general, most of the medium-sized movable shellers have no more than three rubbers. In this research, all six rubbers were used, which is an innovation that has never been thought of before. The focus of this research the rubbers will rotate together at different speeds. But the research with inverter control can determine the speed by determining the factors studied as shown in Table 2.

The process of cracking paddy with six rubber balls has not been reported in the country and abroad. Therefore, in this research, the focus of innovation is to be different from the existing, but the test efficiency results are satisfactory as shown in Table 7. After the best results were obtained from the test. Take control factors as designed from the start. The experiment was repeated five times, and the percentage of broken rice was at ten, but the percentage of good rice was ninety.

It has been shown that the innovative six-rubbers hulling process has the best results and reduced the shelling time by at least twenty-five percent compared to conventional machines on the market and applying the experimental design principles by using the response surface methodology and the design of the central composite yielded significant responses at the confidence level 95 percent. Future work will continue and expand the results of this research. Operations were planned, that is, the control variable was increased to four rice varieties. This makes it more versatile in the brown rice production process. Because of the brown rice production process, there are related factors such as huskers, workers, some days the electricity does not reach the power source, 220 volts. It is difficult to control the season as well as the relative humidity. Such factors affect the process. But careful planning has made this research the most appropriate outcome. The future work will try to make at least more than before. twenty-five percent will make you more confident.

Acknowledgement

Financial support integrated Economic and Social Enhancement Project for Sub-District (1 Tambon 1 University) Rajamangala University of Technology Lanna area of responsibility Nong Phueng Sub-District, Saraphi District, Chiang Mai province name of project/activity in operation revitalizes the community economy in a new way with science. Technology and innovation in the case of Nong Phueng Sub-district, Saraphi District, Chiang Mai Province and support integrated Economic and Social Enhancement Project for Sub-District (1 Tambon 1 University) Chiang Mai Rajabhat University area of responsibility Muang Ngai Sub-District, Chiang Dao District, Chiang Mai province name of project/activity in operation Revitalizes the community economy in a new way with science. Technology and innovation in the case of Muang Ngai Sub-District, Chiang Dao District, Chiang Mai Province are gratefully acknowledged.

ISSN (Online): 0493-2137
E-Publication: Online Open Access
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